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UNITED STATES ARMY
NATICK LABORATORIES
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FOREWORD

Freeze-dried foods have many favorable attributes such as being lightweight with excellent storage stability and good consumer acceptance which make them highly suitable for use in operational rations. However, freeze drying removes moisture without changing the dimensions of the food product. Thus, the dried product has a porous texture and a very low bulk density. Because of the bulk density, work is being performed on compression of freeze-dried foods with the ultimate goal of producing food bars with high bulk densities, but which will rehydrate rapidly to yield a familiar food.

Freeze-dried meat balls and pork sausage links rehydrate rapidly and have high consumer acceptability. Compressed, they would provide definite logistic advantages, not only in operational rations, but also where space is critical such as in submarines.

The work was performed under Project 1J6-62708-D553, Food Processing and Preservation Techniques.

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ABSTRACT

Compressed bars have been developed from freeze-dried meat balls and pork sausage links which show promise for use in operational rations. Compression ratios are 1: 3.7 for the meat balls and 1: 4.5 for the pork sausage links. Rehydration time is about two minutes in hot water.

Introduction

Modern freeze drying techniques permit the production of rapidly rehydrating food products with high consumer acceptance. However, the 60 to 90 percent reduction in weight of the products is accompanied by only a very small reduction in volume. Reducing the volume while retaining the rapid rehydration and high acceptance characteristics of freeze-dried foods offers obvious advantages in terms of transport, storage and ratio of food to packaging material.

Hamdy (1960) reviewed the literature which he claimed covered all the work that had been carried out on the compression of dehydrated foods in the U.S.A., Canada, Australia and the United Kingdom. In all, 33 references were listed covering various phases of the problem. Almost all of them referred to compression of air-dried foods or to compaction by vibration or similar means.

Freeze-dried foods are considerably more bulky than their air-dried counterparts. Their moisture content is usually less than 2 percent and they are very fragile. As a result, they break into a powder when subjected to pressure. Freeze-dried meats when compressed yield bars with little cohesion which, when rehydrated, become finely dispersed slurries.

Hamdy (1962) compressed freeze-dried spinach and cooked ground beef. He found acceptable compressed products could be obtained by increasing the moisture content of spinach at least 9 percent and the beef to at least 3 percent. Ishler (1965) investigated the compression of a broad range of freeze-dried foods. He found that spraying the dehydrated food with water, glycerine, or propylene glycol before compression results in bars with excellent rehydration characteristics and very little fragmentation. This work resulted in a patent (Ishler *et al.*, 1968) which covers spraying freeze-dried cellular foods to 5-13 percent moisture, compressing, and redrying the foods to less than 3 percent moisture.

Buscemi *et al.*, (1964) developed freeze-dried fried meat balls and pork sausage which rehydrated very rapidly. Corn meal was used to improve rehydration. Varying the quantity of corn meal in the formula controls the texture of the rehydrated product so that depending upon the amount of corn meal, the product texture will range from firm to mushy as desired. Compression of these products would provide large volume savings since they have very poor packing factors because of their shape as well as their low densities.

Experimental Methods

Initial observations indicated that both the meat balls and the pork sausage could be compressed and then rehydrated with very little fragmentation provided that they were plasticized by the addition of moisture to the dry product. However, to obtain compressed bars which could be properly

packaged and which would rehydrate fast to yield a product with acceptable texture and flavor, required investigations into formulation, water content before compression, and drying back to below 2 percent moisture. In addition, pressure and dwell times would have to be evaluated.

Basic formula used for the meat balls was:

Ingredient	Percent by weight
Beef	68.50
Corn meal	5.40
Water	24.00
Salt	1.50
Monosodium glutamate	0.05
Pepper, black	0.05
Onion powder	0.50

The beef (U.S. Grade Good top round) was trimmed to approximately 15 percent fat and divided into approximately equal portions, one containing the fatter pieces and the other the lean pieces. Salt was added to the lean portion and the product ground through a plate having 1-inch holes and reground through a plate having 3/8-inch holes. The fatter beef was ground through a plate having 1-inch holes. The seasonings with corn meal and the required amount of water were cooked for 18 minutes. cooled to 40°F., and mixed with the ground fat and lean beef. The mixture was then ground through a plate containing 3/16-inch holes and mechanically formed into meatballs with a Hollymatic 500 machine using 3/4-inch diameter holes in 1/2-inch thick plate. The meat balls were deep fat fried at 375°F. to an internal temperature of 165°F., frozen in a -30°F. blast freezer, and freeze-dried with radiant heat at a platen temperature of 125°F. Final moisture content was approximately 0.5 percent. The dried product was sprayed with water to the moisture content desired and allowed to equilibrate 1 to 3 days in sealed No. 10 cans.

Basic formula used for the pork sausage links was:

Ingredient	Percent by weight
Pork	75.50
Salt	1.20
Corn meal	2.50
Shortening (100 hour)	0.50
Sugar	0.20
Pepper (white)	0.06
Rosemary	0.04
Water	20.00

Pork loins (14-16 lbs.) were boned and trimmed to approximately 20 percent fat and divided into approximately equal portions, one containing the fatter pieces and the other the lean pieces. The lean portion was mixed with salt and then ground through a plate containing 1-inch holes

followed by grinding through a plate with 3/16-inch holes. Subsequent processing was the same as that used for the meat balls except that the links were formed using the Hollymatic 500 with a 5/8-inch plate and holes 5/8 by 3 inches.

Previous in-house work with compressing freeze-dried meats has consistently shown that the best compression is obtained when the dry products are wet back to 10-12 percent moisture. In this study moisture levels of 8, 10, 12 and 14 percent were tested for both the meat balls and the pork sausage. Levels of corn meal tested in the formula for pork sausage were 0, 0.5, 1.5, 2.0, and 2.5 percent and 0, 1.4, 2.4, 3.4, 4.4 and 5.4 percent for the meat balls. The products were wet back to the required moisture by spraying them to the calculated weight and then allowing them to equilibrate in a sealed No. 10 can for at least 2 days. The products were compressed using a Carver laboratory press using a 1 x 3-inch mold and 25 grams of product. The compressed products were dried back to less than 2 percent moisture in a vacuum oven at a low temperature.

Results and Discussion

Meat Balls. Optimum conditions for an acceptable compressed bar as judged by an informal technological panel were:

Corn meal	-	5.4 percent
Moisture	-	12 percent
Pressure	-	7,000 lbs. per sq. inch
Dwell time	-	20 seconds

With these conditions, the bar separated into individual meat balls in about 10 seconds when rehydrated in an excess of hot water (180°F.) and the balls were completely rehydrated within 60 seconds. However, the product had a tendency to pick up excess water and the best results were obtained by pouring the exact amount of water as calculated for complete rehydration on the bar and allowing about 2 minutes for rehydration.

One problem encountered with the meat balls was relaxation of the bar after the pressure was removed. This was overcome by using a 20-second dwell time. It is hoped that further work can result in a reduced dwell time to reduce the production costs.

The amount of corn meal in the formula affected the texture of the final product and the speed of rehydration. However, it did not seem to affect the over rehydration when an excess of water was used.

Pork Sausage Links. Optimum conditions for an acceptable bar were:

Corn meal	-	2.5 percent
Moisture	-	12 percent
Pressure	-	10,000 lbs/sq. inch
Dwell time	-	10 seconds

When rehydrated the product separated into individual links in about 10 seconds and was completely rehydrated in about 60 seconds when placed in an excess of hot water (180°F.). However, the product took up excess water and the best procedure was to use the exact amount of water needed for rehydration. The amount of corn meal did not seem to effect excess water pickup although it did effect the texture.

Compression ratios obtained were:

Pork Sausage	-	1: 4.5
Meat Balls	-	1: 3.7

These ratios for compressed products are also for the same product uncompressed in a No. 10 can with no headspace.

It was found that the compressed products must be dried back to less than 2 percent moisture. Otherwise, onset of a browning reaction occurred within a few days when the products were stored at 100°F. with resulting off odors, color, and flavor.

Freeze-dried meat has a sponge-like internal structure which can be compressed out of shape, but which has a "memory" under certain conditions and will return to its original state when rehydrated. Freeze-dried peas have a skin which has a similar "memory" and will return to their original spherical shape when the product is rehydrated. Ground meat products such as meat balls and pork sausage links have their internal structure destroyed in grinding and do not have a skin in the raw state. However, when they are deep fat fried, a skin of coagulated protein is formed and this skin has the "memory" necessary for successful compression. Characteristics of the skin can be altered by ingredient and processing changes.

When the meat balls and pork sausage links are rehydrated in an excess of hot water, they have a tendency to swell to larger than original size before compression and to take up an excess of water so that they become soggy. Apparently, the skin formed in frying stretches when it becomes wet unlike the skin of a pea which is comparatively non-elastic. The tendency of the products to over-rehydrate limits their usefulness since they will tend to rob water from gravies and sauces when they are used in combination items. However, when the rehydration water is used in the correct quantity, the rehydrated products are of good quality as judged by a technological panel.

As this study has shown, changes in ingredients, processing, and quantity of cornmeal alter the rehydration characteristics. However, it is evident that more basic information is needed on the nature of the film or skin formed during frying so that products may be designed which do not over rehydrate.

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13. ABSTRACT

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